Semivariogram models for estimating fig fly population density throughout the year

Mauricio Paulo Batistella Pasini[(1)], Alessandro Dal'Col Lúcio[(1)] and Alberto Cargnelutti Filho[(1)]

[(1)]Universidade Federal de Santa Maria, Departamento de Fitotecnia, Avenida Roraima, nº 1.000, Prédio 77, Cidade Universitária, Camobi, CEP 97105-900 Santa Maria, RS, Brazil. E-mail: mauricio.pasini@gmail.com, adlucio@ufsm.br, alberto.cargnelutti.filho@gmail.com

Abstract – The objective of this work was to select semivariogram models to estimate the population density of fig fly (*Zaprionus indianus*; Diptera: Drosophilidae) throughout the year, using ordinary kriging. Nineteen monitoring sites were demarcated in an area of 8,200 m^2, cropped with six fruit tree species: persimmon, citrus, fig, guava, apple, and peach. During a 24 month period, 106 weekly evaluations were done in these sites. The average number of adult fig flies captured weekly per trap, during each month, was subjected to the circular, spherical, pentaspherical, exponential, Gaussian, rational quadratic, hole effect, K-Bessel, J-Bessel, and stable semivariogram models, using ordinary kriging interpolation. The models with the best fit were selected by cross-validation. Each data set (months) has a particular spatial dependence structure, which makes it necessary to define specific models of semivariograms in order to enhance the adjustment to the experimental semivariogram. Therefore, it was not possible to determine a standard semivariogram model; instead, six theoretical models were selected: circular, Gaussian, hole effect, K-Bessel, J-Bessel, and stable.

Index terms: *Zaprionus indianus*, geostatistics, integrated pest management, monitoring, regionalized variables, spatial dependence.

Modelos de semivariogramas para estimar a densidade populacional da mosca-do-figo ao longo do ano

Resumo – O objetivo deste trabalho foi selecionar modelos de semivariogramas para estimar a densidade populacional da mosca-do-figo (*Zaprionus indianus*; Diptera: Drosophilidae) ao longo do ano, com uso da krigagem ordinária. Dezenove locais de monitoramento foram demarcados em área de 8.200 m^2, cultivada com seis espécies de frutíferas: caquizeiro, citros, figueira, goiabeira, macieira e pessegueiro. Durante um período de 24 meses, foram realizadas 106 avaliações semanais nesses locais. O número médio de moscas-do-figo capturadas semanalmente por armadilha, por mês, foi submetido aos modelos de semivariogramas circular, esférico, pentaesférico, exponencial, gaussiano, quadrático racional, seno cardinal, K-Bessel, J-Bessel e estável, por meio de interpolação por krigagem ordinária. Os modelos com melhor ajuste foram selecionados a partir da validação cruzada. Cada conjunto de dados (meses) tem uma estrutura de dependência espacial específica, o que torna necessário definir modelos específicos de semivariogramas para melhorar o ajuste ao semivariograma experimental. Portanto, não foi possível definir um modelo padrão de semivariograma; ao invés disso, seis modelos teóricos foram selecionados: circular, gaussiano, seno cardinal, K-Bessel, J-Bessel e estável.

Termos para indexação: *Zaprionus indianus*, geoestatística, manejo integrado de pragas, monitoramento, variáveis regionalizadas, dependência espacial.

Introduction

The fig fly, *Zaprionus indianus* (Diptera: Drosophilidae), is a major pest in fig (*Ficus carica* L.) crops. It attacks fig fruit at the beginning of maturation, laying its eggs in the ostiole, which makes them unfit for consumption and processing. During the off-season, the fig fly searches for other hosts and is associated with decaying fruits. There is no information on the spatial distribution of the fig fly throughout the year, neither on the use of ordinary kriging to estimate its population density. According to Lasmar et al. (2012), the spatial distribution pattern of insects may vary over time, and its knowledge can help pest management by assisting in decision making, promoting local control of insect pest infestations, and reducing production costs with less use of insecticides, diminishing impacts on the environment. Therefore,

DOI: 10.1590/S0100-204X2014000700001

the knowledge of pest behavior, feeding preferences, and habitats throughout the year is important for the establishment of an integrated pest management (Pasini et al., 2011).

Insect populations in orchards can be estimated by interpolation procedures, which generate continuous information surfaces through punctual sample units (Webster & Oliver, 2007). Among the interpolation methods, ordinary kriging is one of the most used (Silva et al., 2010; Bottega et al., 2013). This method uses the spatial dependence among neighboring samples and estimates variable values in the semivariogram, at any position within the experimental area (Webster & Oliver, 2007). Mello et al. (2005) highlight that the semivariogram has a pivotal importance for geostatistics, since it is able to describe the structure of spatial dependence, and it is crucial for determining the interpolator, having direct influence on the estimated values.

A valid semivariogram model has to be selected, and the model parameters have to be estimated before kriging (Gundogdu & Guney, 2007). According to Webster & Oliver (2007), the selection of a model that soundly represents the semivariances is very important for kriging. A wrong choice of a theoretical semivariogram model generates errors in the estimates, overestimating or underestimating values.

Gundogdu & Guney (2007) tested the circular, spherical, tetraspherical, pentaspherical, exponential, Gaussian, rational quadratic, hole effect, K-Bessel, J-Bessel, and stable models to determine underground water levels, and found that the rational quadratic one had the best fit. Farias et al. (2008) studied the spatial distribution of the fall armyworm (*Spodoptera frugiperda*) and observed that the spherical model had the best fit. Lasmar et al. (2012) determined the spatial distribution of ants in a eucalyptus (*Eucalyptus* spp.) plantation using the spherical, exponential, and Gaussian semivariogram models, and reported the best fit for the exponential model. Mora & Beer (2013) used the spherical model to study the spatial variability of coffee (*Coffea arabica* L.) fine roots, under *Erythrina* shade. Noetzold et al. (2014) evaluated the spatial variability of *Colletotrichum truncatum* on soybean (*Glycine max* L.) field with the spherical, exponential, Gaussian, and K-Bessel models, and found the best adjustment for the spherical model. However, most studies with geostatistical models use few semivariograms and do not contemplate the possibility that data sets may show a different spatial structure with time.

The objective of this work was to select semivariogram models to estimate the population density of fig fly throughout the year, using ordinary kriging.

Materials and Methods

The study was carried out in the municipality of Santa Maria, in the state of Rio Grande do Sul, Brazil (29º43'26"S, 53º43'4"W), in 8,200 m^2, cropped with six fruit tree species: persimmon (*Diospyros kaki* L.), citrus (*Citrus* spp.), fig, guava (*Psidium guajava* L.), apple (*Malus domestica* Borkh.), and peach [*Prunus persica* (L.) Batsch]. The plants were eight-years-old, spaced at 2x3 m, and the plots were distributed in bands of length varying from 50 to 80 m. According to Köppen’s classification, local climate is Cfa, subtropical humid, without dry season and with hot summers (Heldwein et al., 2009).

Nineteen monitoring points were randomly distributed in the plots, using one trap for each 430 m^2. The monitoring sites were demarcated with the aid of a global navigation satellite system (GNSS) receiver, which registered their geographical coordinates. At each monitoring point, a bottle fly trap was placed on a fruit tree 0.5 m above ground and protected from the sunlight from the east side of the canopy. The traps were composed of 0.6 L PET bottles, with two 0.8 cm holes to allow the entry of insects. The bottle traps contained attractive solution of fig juice and water (50:50%) with a total volume of 200 mL. Each trap was used for a 28 day period, as in Pasini et al. (2011). The traps remained in the field from September 30th, 2009, to October 4th, 2011, and the trapped insects were collected weekly and screened. A total of 106 evaluations were performed. Adult fig fly individuals were identified and quantified based on Yassin & David (2010).

The number of adult fig flies captured weekly by the traps was organized accordingly to the 24 month period. The following descriptive statistics were estimated for each month: average, median, standard deviation, standard error, kurtosis, asymmetry, and coefficient of variation. Data with normal distribution or that showed negative asymmetry was not transformed (Yamamoto

& Landin, 2013). The hypothesis of normality of the data was tested by the Anderson-Darling test, at 5% probability, and, if not satisfied, the data were subjected to the Box-Cox transformation (Box & Cox, 1964). Then, the data were subjected to geostatistical analysis in order to verify the existence of spatial dependence; if existent, its degree was quantified by comparing the models to the isotropic experimental semivariogram, estimated by

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2,$$

in which (h) is the semivariance and N(h) is the number of $Z(x_i)$ and $Z(x_i+h)$ pairs measured, separated by an h vector.

From the experimental semivariograms, 11 theoretical models of semivariograms were adjusted (Johnson et al., 2001): circular,

$$\gamma(h) = \frac{2C_0 + C_1}{\pi}\left[\frac{h}{a}\sqrt{1-\left(\frac{h}{a}\right)^2} + \arcsin\frac{h}{a}\right]$$

for $0 \leq h \leq a$, and $\gamma(h; \theta) = C_0 + C_1$ for $a<h$; spherical,

$$\gamma(h) = C_0 + C_1\left[\frac{3}{2}\frac{h}{a} - \frac{1}{2}\left(\frac{h}{a}\right)^3\right]$$

for $0 \leq h \leq a$, and $\gamma(h; \theta) = C_0 + C_1$ for $a<h$; pentaspherical,

$$\gamma(h) = C_0 + C_1\left[\frac{15}{8}\frac{h}{a} - \frac{5}{4}\left(\frac{h}{a}\right)^3 + \frac{3}{8}\left(\frac{h}{a}\right)^5\right]$$

for $0 \leq h \leq a$, and $\gamma(h; \theta) = C_0 + C_1$ for $a<h$; exponential,

$$\gamma(h) = C_0 + C_1\left[1 - e^{-3\left(\frac{h}{a}\right)}\right]$$

for all h; Gaussian,

$$\gamma(h) = C_0 + C_1\left[1 - e^{-3\left(\frac{h}{a}\right)^2}\right]$$

for all h; rational quadratic,

$$\gamma(h) = C_0 + C_1 \frac{19\left(\frac{h}{a}\right)^2}{1+19\left(\frac{h}{a}\right)^2}$$

for all h; hole effect, 0 for h=0 and

$$\gamma(h) = C_0 + C_1 \frac{1 - \sin\left(\frac{2\pi h}{a}\right)}{\sin\left(\frac{2\pi h}{a}\right)}$$

for $h \neq 0$; K-Bessel,

$$\gamma(h) = C_0 + C_1\left[1 - \frac{\left(\frac{\Omega_{\theta_k} h}{a}\right)^{\theta_k}}{2^{\theta_k - 1}\Gamma(\theta_k)} K_{\theta_k}\left(\frac{\Omega_{\theta_k} h}{a}\right)\right]$$

for all h, in which $\Omega_{\theta k}$ is a value found numerically so that $\gamma(a)$ - 0.95 $(C_0 + C_1)$ for any θ_k, $\Gamma(\theta_k)$ is the gamma function,

$$\Gamma(y) = \int_0^\infty xy^{-1} \exp(-x)\, dx,$$

and $K_{\theta k}$ is the modified Bessel function of the second kind of order θ_k; J-Bessel,

$$\gamma(h) = C_0 + C_1\left[1 - \frac{2^{\theta_d}\Gamma(\theta_d + 1)}{\left(\frac{\Omega_{\theta_d} h}{a}\right)^{\theta_d}} J_{\theta_d}\left(\frac{\Omega_{\theta_d} h}{a}\right)\right]$$

for all h, in which $C_0 + C_1 \geq 0$, $a \geq 0$, $\theta \geq 0$, $\Omega_{\theta d}$ must satisfy B = a, B > 0, $\gamma(B) = C_0 + C_1$, $\gamma(B) = C_0 + C_1$, $\gamma'(B) < 0$, and $J_{\theta d}$ is the J-Bessel function; and stable,

$$\gamma(h) = C_0 + C_1\left[1 - e^{\left(-3\left(\frac{h}{a}\right)^{\theta e}\right)}\right]$$

for all h, in which $C_0 + C_1$ and $0 \leq \theta_e \leq 2$.

Using the algorithm of weighted least squares, these models were adjusted to the experimental semivariogram, and the following model parameters were defined: nugget effect (C_0), sill (C_0+C_1), and range (a).

In order to verify the existence of spatial dependence, the spatial dependence index (SDI) was applied, which is the ratio representing the percentage of data variability explained by spatial dependence. The SDI is estimated with the expression: SDI = [C1/(C0 + C1)]100, being classified as strong (SDI>75%), medium (25<SDI≤75%), and low (SDI≤25%).

After the confirmation of spatial dependence, inferences were performed by ordinary kriging, following Johnson et al. (2001), which allowed for the estimation of values at locations not measured. For ordinary kriging, non-biased estimates, with minimum deviation from the known values, are interpolated, considering the spatial variability structure of the attribute (Webster & Oliver, 2007).

The semivariogram model was selected according to the Webster & Oliver (2007) cross-validation technique. Goovaerts (1997) argues that cross-validation allows comparing the impact of interpolators among the real estimated values, in which the model with more accurate predictions is chosen. Faraco et al. (2008) considered the cross-validation criterion as the most adequate for choosing the best semivariogram adjustment. Linear regression was used as a first indicator of cross-validation, in which the estimated values (dependent variable) were crossed with the sampled values (independent variable). The best adjustments are obtained when the estimation of the intercept a approaches zero, and the linear b and determination R^2 coefficients approach 1.

As a second indicator, the mean prediction error ($\bar{E}$) was used, estimated by the expression:

$$\bar{E} = \frac{\sum_{i=1}^{n} [\hat{Z}(s_i) - z(s_i)]}{n},$$

in which z is the observed value and $\hat{z}$ is the estimated value. As a third indicator, the standard deviation of the prediction error (SD) was used, estimated by the expression:

$$SD = \sqrt{\frac{\sum_{i=1}^{n} \{[\hat{Z}(s_i) - z(s_i)] - E\}^2}{n-1}}.$$

As a fourth indicator, the coefficient of variation (VC) was used, and as a fifth, the mean prediction absolute error ($\bar{A}\bar{E}$), estimated by the expression:

$$\overline{AE} = \frac{\sum_{i=1}^{n} |[\hat{Z}(s_i) - z(s_i)]|}{n}.$$

The root-mean-square prediction error (RMS) was used as a sixth indicator, estimated by the expression:

$$RMS = \sqrt{\frac{\sum_{i=1}^{n} [\hat{Z}(s_i) - z(s_i)]^2}{n}}.$$

For these parameters, the closer to zero, the best the adjustment of the model. As a seventh indicator, the root-mean-square standardized prediction error (RMSS) was used, estimated by the expression:

$$RMSS = \sqrt{\frac{\sum_{i=1}^{n} [(\hat{Z}(s_i) - z(s_i))/ \sigma(s_i)]^2}{n}}.$$

For this parameter, the best adjustment is obtained when it approaches 1.

The cross-validation grades for the indicators varied from 1 to 10, according to the selected criterion of each indicator: for b, R^2, and RMSS, values closer to 1 received the grade 10, whereas the most distant values received the grade 1; for the estimates $\bar{E}$, SD, VC, $\bar{A}\bar{E}$, and RMS, values closer or equal to zero received the grade 10, and the most distant values received the grade 1. The model with the highest sum of grades was chosen.

Results and Discussion

During the 24 month monitoring period, 47,193 adult fig flies were captured, with weekly average of 23.5 adults captured per trap. In the first 12 months, 23,104 adult fig flies were captured, with weekly average of 22.9 adults per trap. In the last 12 months, 24,089 adult flies were captured, with a daily average of 23.9 adults per trap. These weekly averages were lower than the ones reported by Raga et al. (2006), Pasini et al. (2011), Pasini & Link (2011), but they represent a considerably longer period.

During the two experimental years, the highest capture levels were registered in March, with 79.2 and 84.4 fig fly adults per trap per week in the first and in the second year, respectively. April had the next higher capture levels, with 51.1 and 49 adults per trap per week, respectively. These values are high when compared to those found by Raga et al. (2006), Pasini et al. (2011), and Pasini & Link (2011). Moreover, they were obtained during the maturation period of the figs and, therefore, represent a high damage threat for the fruit (Table 1). August and September were the months with lower capture rate, in both years, possibly because of the lack of food and low temperatures. During these months, the average weekly number of adult individuals captured per trap was inferior to seven.

The collected data were rather variable, in both years, as attested by the high coefficient of variation (CV≥48%) (Table 1). This variability is possibly explained by the great diversity of fruit trees existing in the orchard. According to Pasini et al. (2011), fig fly has a great number of hosts and its development is close to the substrate, which influences the distribution of pest population in the orchards and favors the presence of outliers.

In all tested semivariograms, theoretical models show strong spatial dependence (Tables 2 and 3), which can highly contribute to data variability and, therefore, may be used in the ordinary kriging interpolator.

After the interpolation, semivariogram models with higher sum for cross-validation indicators were chosen (Tables 4 and 5). Different semivariogram models were obtained for the different months and years, which agrees with the hypothesis of Gundogdu & Guney (2007) that each data set presents a different spatial structure and that it is necessary to define a semivariogram model with the best fit to each one of them.

In the first year, the circular model had a higher sum of cross-validation indicators in December, June, and July; the hole effect model, in October, January, March, and August; and the stable model, in November. In the second year, the Gaussian model had the best fit in October, November, December, February, July, and August; the hole effect model, in January, March, May, and September; the K-Bessel model, in April; and the J-Bessel model, in June. This result does not agree with those reported by other authors, who found that the spherical and exponential

Table 1. Descriptive statistics of the weekly average number of fig flies (*Zaprionus indianus*; Diptera: Drosophilidae) captured over different months, in the first and second years of monitoring.

Statistics	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
						First year						
Average	6.9	12.3	16.7	20.1	25.5	79.2	51.1	29.2	19.9	6.0	3.1	3.6
Median	5.5	10.3	14.0	15.8	23.8	36.6	46.5	27.8	14.2	4.5	3.0	2.8
Minimum	1.8	5.8	5.2	8.5	7.0	8.4	8.3	2.0	2.2	1.0	0.8	0.3
Maximum	18.3	28.3	39.2	45.0	53.8	306.8	153.8	54.5	59.8	14.5	7.0	13.5
Interval	16.5	22.5	34.0	36.5	46.8	298.4	145.5	52.5	57.6	13.5	6.2	13.3
Standard deviation	4.5	5.9	9.8	11.2	14.3	103.7	48.1	18.1	17.3	4.3	1.6	3.5
Standard error	1.0	1.4	2.2	2.6	3.3	23.8	11.0	4.2	4.0	1.0	0.4	0.8
Kurtosis	0.9	1.8	1.0	0.4	-0.3	1.4	0.0	-1.4	0.2	-0.7	0.5	2.9
Asymmetry	1.2	1.5	1.4	1.2	0.8	1.7	1.1	0.0	1.0	0.8	0.6	1.8
Coefficient of variation (%)	65	48	58	55	56	131	94	62	87	72	50	97
Normality (p-value)	0.04	0.00	0.00	0.01	0.08*	0.00	0.00	0.25*	0.04	0.04	0.73*	0.00
Box-Cox (λ)	0	-0.58	0	-0.63	-	-0.33	0	-	0	0	-	0
Normality (p-value)	0.76*	0.85*	0.51*	0.41*	-	0.11*	0.12*	-	0.42*	0.67*	-	0.86*
						Second year						
Average	8.5	15.0	20.4	19.8	26.9	84.4	49.5	26.0	15.7	7.2	5.0	4.9
Median	5.0	11.6	14.0	15.0	25.0	49.8	66.5	33.4	13.8	5.0	3.2	3.0
Minimum	0.8	1.2	1.3	8.5	8.5	8.8	1.5	1.6	2.5	0.8	0.8	0.6
Maximum	29.5	36.8	46.8	45.8	58.8	317.4	117.8	43.6	40.3	23.3	11.6	14.2
Interval	28.8	35.6	45.5	37.3	50.3	308.6	116.3	42.0	37.8	22.5	10.8	13.6
Standard deviation	8.5	10.6	14.3	11.2	15.5	107.8	39.8	15.2	11.9	6.0	3.4	4.3
Standard error	1.9	2.4	3.3	2.6	3.6	24.7	9.1	3.5	2.7	1.4	0.8	1.0
Kurtosis	1.8	-0.2	-0.7	0.6	0.0	1.3	-1.7	-1.3	0.1	1.9	-1.1	0.1
Asymmetry	1.5	0.7	0.7	1.3	0.9	1.6	0.1	-0.6	1.0	1.5	0.5	1.1
Coefficient of variation (%)	100	70	70	56	57	127	80	58	76	82	67	87
Normality (p-value)	0.00	0.15*	0.05	0.00	0.05	0.00	0.00	0.00	0.03	0.01	0.03	0.00
Box-Cox (λ)	0	-	0.43	-0.78	0	-0.28	0.33	-	0	0	0	0
Normality (p-value)	0.87*	-	0.41*	0.45*	0.58*	0.09*	0.11*	-	0.51*	0.93*	0.20*	0.63*

*Normal data, according to the Anderson-Darling test, at 5% probability. Number of traps = 19.

Table 2. Nugget effect (C_0), sill (C_1), range (a), gamma function (Γ), and spatial dependence index (SDI) estimated in the first year of evaluation, for the following semivariogram models: C, circular; S, spherical; P, pentaspherical; E, exponential; G, Gaussian; R, rational quadratic; H, hole effect; K, K-Bessel; J, J-Bessel; and St, stable.

Model	C_0	C_1	a	Γ	SDI[1]	C_0	C_1	a	Γ	SDI	C_0	C_1	a	Γ	SDI
			October					November					December		
C	0	0.4334	42.2	-	S	0	0.0089	42.2	-	S	0	0.3437	78.1	-	S
S	0	0.5043	32.3	-	S	0	0.0101	32.3	-	S	0	0.3681	97.7	-	S
P	0.0034	0.4754	36.8	-	S	0	0.0093	32.9	-	S	0	0.3731	105.3	-	S
E	0	0.4876	33.3	-	S	0.0002	0.0089	92.5	-	S	0	0.3659	105.3	-	S
G	0	0.3639	42.2	-	S	0	0.0075	42.3	-	S	0	0.3147	47.8	-	S
R	0.0005	0.4801	33.2	-	S	0.0007	0.0079	92.4	-	S	0	0.3621	119.1	-	S
H	0	0.3875	42.2	-	S	0	0.0091	50.3	-	S	0	0.2567	65.5	-	S
K	0	0.5432	32.1	2.03	S	0	0.0104	42.2	5.32	S	0	0.3214	52.3	10	S
J	0	0.3993	40.7	0.36	S	0	0.0089	56.9	0.07	S	0	0.2902	65.8	4.25	S
St	0	0.5226	32.1	-	S	0	0.0075	42.2	-	S	0	0.3147	47.8	-	S
			January					February					March		
C	0	0.0072	80.4	-	S	0	289.06	91.1	-	S	0	0.2414	158.1	-	S
S	0	0.0103	119.7	-	S	0	261.69	105.3	-	S	0	0.0723	59.1	-	S
P	0	0.0082	105.3	-	S	0	269.07	105.3	-	S	0	0.1019	89.6	-	S
E	0	0.0082	105.3	-	S	0	265.15	105.3	-	S	0	0.1451	105.3	-	S
G	0	0.0074	48.2	-	S	0	258.53	56.1	-	S	0	0.0882	49.9	-	S
R	0	0.0051	64.3	-	S	0.2344	234.44	78.9	-	S	0	0.1307	131.2	-	S
H	0	0.0055	60.1	-	S	0	199.81	73.6	-	S	0	0.0097	47.8	-	S
K	0	0.0101	90.1	10	S	0	257.11	90.2	0.96	S	0	0.0657	46.1	10	S
J	0	0.0078	105.3	3.39	S	0	222.08	78.9	10	S	0	0.0761	47.4	3.6	S
St	0	0.0101	119.1	-	S	0	270.01	90.5	-	S	0	0.0583	32.3	-	S
			April					May					June		
C	0	1.0361	60.3	-	S	0	250.1	40.2	-	S	0	1.3001	43.7	-	S
S	0	0.9948	60.3	-	S	0	250.1	38.1	-	S	0	1.3021	49.3	-	S
P	0	1.2821	105.3	-	S	0	243.7	42.2	-	S	0	1.1028	54.4	-	S
E	0	1.2967	105.3	-	S	0	310.3	42.9	-	S	0	1.2534	59.7	-	S
G	0	0.8029	47.3	-	S	0	210.1	42.2	-	S	0	1.9211	50.1	-	S
R	0.0012	1.2652	105.3	-	S	0	324.2	60.8	-	S	0	1.4123	79.6	-	S
H	0	0.8091	53.4	-	S	0	319.9	40.1	-	S	0	1.5141	65.6	-	S
K	0	0.8686	51.9	10	S	0	309.4	46.9	0.34	S	0	1.2678	60.1	0.57	S
J	0	0.8893	55.9	3.28	S	0	280.2	50.1	10	S	0	0.9232	40.2	9.86	S
St	0	0.8029	56.5	-	S	0	309.5	46.6	-	S	0	1.2673	60.1	-	S
			July					August					September		
C	0	0.6529	42.2	-	S	0	3.1175	40.2	-	S	0	1.1203	54.9	-	S
S	0	0.7022	42.2	-	S	0	3.1337	41.5	-	S	0	1.0731	58.8	-	S
P	0	0.713	50.7	-	S	0	3.0217	42.2	-	S	0	1.2344	88.3	-	S
E	0	0.7417	57.8	-	S	0	3.1036	46.1	-	S	0	1.3016	107.5	-	S
G	0	0.6542	39.3	-	S	0	3.2561	42.2	-	S	0	1.0357	41.9	-	S
R	0	0.7255	62.7	-	S	0	3.1081	52.5	-	S	0	1.2774	106.4	-	S
H	0.0004	0.4244	59.2	-	S	0	2.7321	54.5	-	S	0	0.9116	69.8	-	S
K	0	0.7318	42.2	1.96	S	0	3.2715	42.2	10	S	0	1.0561	45.1	9.93	S
J	0	0.6161	47.6	10	S	0	2.6931	54.4	3.41	S	0	1.0182	61.4	3.91	S
St	0	0.7301	42.2	-	S	0	3.2847	34.5	-	S	0	1.0551	44.2	-	S

[1]S, small, SDI>75%; M, medium, 25<SDI≤75%; L, large, SDI≤25%.

models predominate (Ellsbury et al., 1998; Farias et al., 2008; Dinardo-Miranda & Fracasso, 2010; Lasmar et al., 2012). Gundogdu & Guney (2007) evaluated a higher number of theoretical semivariograms and also observed a pattern of chosen models different than that reported in other works.

Table 3. Nugget effect (C_0), sill (C_1), range (a), gamma function (Γ), and spatial dependence index (SDI) estimated in the second year of evaluation, for the following semivariogram models: C, circular; S, spherical; P, pentaspherical; E, exponential; G, Gaussian; R, rational quadratic; H, hole effect; K, K-Bessel; J, J-Bessel; and St, stable.

Model	C_0	C_1	a	Γ	SDI[(1)]	C_0	C_1	a	Γ	SDI	C_0	C_1	a	Γ	SDI
		October					November					December			
C	0	1.3901	32.1	-	S	0	154.74	42.2	-	S	0	10.46	42.2	-	S
S	0	1.3751	33.2	-	S	0	149.71	45.2	-	S	0	13.7	48.5	-	S
P	0	1.3803	33.2	-	S	0	116.69	40.8	-	S	0	10.67	49.5	-	S
E	0	1.4401	40.2	-	S	0	117.41	40.3	-	S	0	9.02	40.2	-	S
G	0	1.8020	42.2	-	S	0	145.78	42.2	-	S	0	10.31	42.2	-	S
R	0	1.4185	40.2	-	S	0	168.72	83.7	-	S	0	8.86	32.2	-	S
H	0	1.5323	44.3	-	S	0	109.34	52.9	-	S	0	9.34	48.2	-	S
K	0	1.7536	42.2	2.52	S	0	147.11	42.2	4.13	S	0	10.64	42.2	1.44	S
J	0	1.7228	45.7	0.51	S	0	117.51	49.7	0.04	S	0	6.27	52.3	0.01	S
St	0	1.8538	42.2	-	S	0	163.82	42.2	-	S	0	9.64	42.2	-	S
		January					February					March			
C	0	0.0038	98.3	-	S	0	0.4888	97.4	-	S	0	0.3369	105.3	-	S
S	0	0.0041	105.3	-	S	0	0.4811	109.9	-	S	0	0.1145	68.5	-	S
P	0	0.0041	149.1	-	S	0	0.4309	105.3	-	S	0	0.1103	51.1	-	S
E	0	0.0032	105.3	-	S	0	0.4283	126.9	-	S	0	0.2011	142.1	-	S
G	0	0.0031	105.3	-	S	0	0.0171	93.6	-	S	0	0.1872	85.1	-	S
R	0	0.0021	51.9	-	S	0	0.2781	77.9	-	S	0	0.1968	105.3	-	S
H	0	0.0029	136.1	-	S	0	0.4156	101.9	-	S	0	0.1111	49.9	-	S
K	0	0.0039	100.3	10	S	0	0.5987	136.1	1.81	S	0	0.1246	50.1	10	S
J	0	0.0032	129.3	3.21	S	0	0.3926	105.3	3.01	S	0	0.1093	75.8	3.5	S
St	0	0.0041	158.1	-	S	0	0.4932	105.3	-	S	0	0.1272	50.1	-	S
		April					May					June			
C	0	8.682	51.2	-	S	0	237.76	105.3	-	S	0	1.1981	87.1	-	S
S	0	10.851	58.6	-	S	0	216.59	111.6	-	S	0	0.8855	67.5	-	S
P	0	10.796	60.8	-	S	0	80.831	48.9	-	S	0	0.9912	84.3	-	S
E	0	15.911	135.3	-	S	0	84.254	47.8	-	S	0	0.9624	105.3	-	S
G	0	9.135	66.5	-	S	0	214.98	74.4	-	S	0	1.2011	78.1	-	S
R	0	15.549	105.3	-	S	0	83.801	32.9	-	S	0.02	0.9161	105.3	-	S
H	0	11.291	98.3	-	S	0	158.92	99.2	-	S	0	0.8441	81.3	-	S
K	0	11.071	76.4	10	S	0	223.43	81.1	10	S	0	0.9258	74.6	1.01	S
J	0	10.064	95.67	3.31	S	0	192.55	100.4	3.31	S	0	0.9416	93.2	10	S
St	0	9.135	66.58	-	S	0	207.35	72.5	-	S	0	0.9294	74.1	-	S
		July					August					September			
C	0	1.0955	52.8	-	S	0	0.6881	42.3	-	S	0	0.8239	40.2	-	S
S	0	0.9295	48.7	-	S	0	0.7098	50.1	-	S	0	0.8429	41.9	-	S
P	0	0.9265	58.1	-	S	0	0.6968	55.4	-	S	0	0.0328	54.9	-	S
E	0	0.9554	68.1	-	S	0	0.7407	66.1	-	S	0	0.9983	70.5	-	S
G	0	1.0938	46.3	-	S	0	0.9739	48.7	-	S	0	1.2975	62.2	-	S
R	0.038	0.8966	74.1	-	S	0	0.7333	73.3	-	S	0	0.9359	67.4	-	S
H	0	0.9123	63.1	-	S	0	0.6876	55.4	-	S	0	0.8252	56.4	-	S
K	0	0.9902	57.5	1.04	S	0	0.7211	44.5	2.37	S	0	0.9697	57.5	0.74	S
J	0	0.9084	59.7	10	S	0	0.6726	53.4	2.57	S	0	0.8481	56.1	1.02	S
St	0	0.9688	51.5	-	S	0	0.8213	51.1	-	S	0	0.8749	42.2	-	S

[(1)]S, small, SDI>75%; M, medium, 25<SDI≤75%; L, large, SDI≤25%.

Table 4. Cross-validation indicators and grades attributed (in brackets), in the first year of evaluation, obtained from ordinary kriging, for the following semivariogram models: C, circular; S, spherical; P, pentaspherical; E, exponential; G, Gaussian; R, rational quadratic; H, hole effect; K, K-Bessel; J, J-Bessel; and St, stable.

Indicator[(1)]	C	S	P	E	G	R	H	K	J	St
					October					
b	0.5(8)	0.3(3)	0.2(1)	0.2(1)	0.6(10)	0.2(1)	0.3(3)	0.3(3)	0.3(3)	0.2(1)
a	3.8(6)	5.2(3)	5.0(3)	5.5(2)	2.7(10)	5.8(1)	4.3(5)	5.2(3)	4.7(4)	5.6(1)
R^2	0.4(10)	0.3(5)	0.3(5)	0.2(1)	0.4(10)	0.2(1)	0.4(10)	0.3(5)	0.4(10)	0.3(5)
$\bar{E}$	0.0(10)	-0.1(5)	0.0(10)	0.0(10)	-0.2(1)	0.0(10)	0.1(5)	-0.1(5)	0.2(1)	-0.1(5)
SD	3.6(7)	3.7(6)	3.8(5)	3.9(4)	4.2(1)	4.1(3)	3.4(10)	3.7(6)	3.5(8)	3.9(4)
VC	340(3)	68(5)	384(2)	391(1)	21(10)	257(4)	23(9)	57(7)	19(10)	67(6)
$\overline{AE}$	2.9(4)	2.8(6)	2.9(4)	3.0(2)	3.1(1)	3.1(1)	2.6(10)	2.8(6)	2.7(8)	3.0(2)
RMS	3.5(8)	3.6(6)	3.7(4)	3.8(3)	4.1(1)	3.9(2)	3.4(10)	3.6(6)	3.4(10)	3.8(3)
RMSS	0.9(10)	0.6(3)	0.6(3)	0.6(3)	1.4(6)	0.6(3)	0.7(1)	0.6(3)	0.6(3)	0.6(3)
Σ notes	60	47	37	27	50	26	63	44	57	30
					November					
b	0.5(4)	0.4(1)	0.4(1)	0.4(1)	0.8(7)	0.4(1)	0.8(7)	0.6(5)	1.0(10)	0.8(7)
a	5.7(6)	6.7(5)	7.4(1)	7.2(2)	2.8(8)	7.0(4)	2.2(9)	4.3(7)	0.6(10)	2.8(8)
R^2	0.8(10)	0.7(5)	0.6(1)	0.6(1)	0.8(10)	0.7(5)	0.8(10)	0.8(10)	0.8(10)	0.8(10)
$\bar{E}$	0.3(3)	0.1(10)	0.1(10)	0.1(10)	0.1(10)	0.1(10)	-0.2(6)	0.1(10)	-0.5(1)	0.1(10)
SD	3.3(6)	3.7(5)	4.1(1)	4.0(3)	2.4(10)	3.9(4)	2.4(10)	2.7(7)	2.6(8)	2.4(10)
VC	10(8)	41(1)	37(3)	38(2)	21(6)	37(4)	12(9)	25(5)	5(10)	21(7)
$\overline{AE}$	2.6(6)	2.9(4)	3.2(1)	3.1(2)	2.0(10)	3.0(3)	2.0(10)	2.3(8)	2.0(10)	2.0(10)
RMS	3.3(5)	3.6(4)	4.0(1)	3.9(2)	2.4(10)	3.8(3)	2.4(10)	2.7(7)	2.6(8)	2.4(10)
RMSS	0.6(5)	0.5(1)	0.5(1)	0.5(1)	0.8(10)	0.5(1)	0.5(1)	0.5(1)	0.6(5)	0.8(10)
Σ notes	44	36	20	24	81	35	62	50	72	84
					December					
b	0.6(3)	0.6(3)	0.6(3)	0.5(1)	0.8(10)	0.7(6)	0.7(6)	0.7(6)	0.8(10)	0.8(10)
a	6.4(3)	6.4(3)	6.6(2)	8.1(1)	4.1(8)	5.6(6)	5.9(5)	4.2(7)	3.8(10)	4.1(8)
R^2	0.9(10)	0.8(5)	0.8(5)	0.7(1)	0.7(1)	0.7(1)	0.8(5)	0.7(1)	0.7(1)	0.7(1)
$\bar{E}$	0.2(1)	0.2(1)	0.2(1)	0.1(5)	0.0(10)	0.2(1)	0.1(5)	0.0(10)	-0.1(5)	0.0(10)
SD	5.1(9)	5.1(9)	5.2(8)	5.8(1)	5.3(6)	5.1(9)	4.6(10)	5.2(8)	5.5(3)	5.3(6)
VC	21(10)	21(9)	34(8)	68(4)	532(2)	26(8)	39(7)	123(3)	54(5)	736(1)
$\overline{AE}$	3.3(8)	3.4(6)	3.4(6)	3.9(1)	3.4(6)	3.2(10)	3.2(10)	3.3(8)	3.5(4)	3.4(6)
RMS	5.0(8)	5.0(8)	5.1(6)	5.7(1)	5.2(5)	5.0(8)	4.5(10)	5.1(6)	5.4(2)	5.2(4)
RMSS	0.7(4)	0.7(4)	0.7(4)	0.6(1)	1.0(10)	0.8(6)	0.6(1)	0.9(8)	1.1(8)	1.0(10)
Σ notes	60	48	42	16	58	55	59	57	48	54
					January					
b	0.6(8)	0.6(8)	0.5(6)	0.4(4)	0.5(6)	0.3(2)	0.6(8)	0.7(10)	0.1(1)	0.5(6)
a	9.0(7)	8.8(8)	9.6(5)	11.5(3)	10.1(4)	14.0(2)	8.1(9)	7.9(10)	30.1(1)	9.5(6)
R^2	0.6(10)	0.6(10)	0.5(8)	0.5(8)	0.2(2)	0.3(6)	0.6(10)	0.1(2)	0.0(1)	0.5(8)
$\bar{E}$	0.3(8)	-0.1(10)	-0.1(10)	-0.4(6)	-1.6(3)	0.3(8)	0.5(4)	-8.2(2)	-29.3(1)	-0.3(8)
SD	7.3(9)	7.5(8)	7.7(7)	8.1(5)	11.5(3)	9.1(4)	7.0(10)	26.5(2)	67.1(1)	7.9(6)
VC	28(4)	127(1)	52(2)	18(6)	7(8)	26(5)	15(7)	3(9)	2(10)	29(3)
$\overline{AE}$	5.0(9)	5.1(8)	5.3(7)	5.9(5)	7.8(3)	6.6(4)	4.9(10)	19.0(2)	45.3(1)	5.4(6)
RMS	7.1(9)	7.3(8)	7.5(7)	7.9(5)	11.3(3)	8.9(4)	6.9(10)	27.1(2)	71.6(1)	7.7(6)
RMSS	1.3(4)	1.2(6)	1.1(8)	0.8(6)	2.0(1)	1.0(10)	0.9(8)	2.0(1)	2.0(1)	1.2(6)
Σ notes	68	67	60	48	33	45	76	40	18	55
					February					
b	0.7(10)	0.6(5)	0.6(5)	0.6(5)	0.7(10)	0.5(1)	0.7(10)	0.7(10)	0.7(10)	0.6(5)
a	8.2(8)	8.4(6)	8.9(4)	11.0(2)	8.5(5)	12.4(1)	6.4(10)	8.3(7)	7.5(9)	8.9(4)
R^2	0.7(10)	0.7(10)	0.7(10)	0.6(1)	0.7(10)	0.6(1)	0.7(10)	0.7(10)	0.7(10)	0.6(1)
$\bar{E}$	0.6(4)	0.6(4)	0.6(4)	0.3(6)	-0.1(10)	0.3(6)	-0.4(4)	-0.2(8)	-0.4(6)	0.7(1)
SD	8.3(5)	8.3(5)	8.5(4)	8.7(3)	7.8(10)	9.4(1)	8.1(7)	7.9(9)	8.1(7)	8.8(2)
VC	13(10)	14(8)	15(7)	28(4)	77(1)	33(3)	22(5)	36(2)	22(6)	13(10)
$\overline{AE}$	6.0(6)	6.0(6)	6.1(4)	6.1(4)	5.6(10)	6.8(1)	6.0(6)	5.8(8)	6.0(6)	6.4(2)
RMS	8.1(5)	8.1(5)	8.3(4)	8.5(3)	7.6(10)	9.1(1)	7.8(7)	7.7(8)	7.9(6)	8.6(2)
RMSS	0.9(10)	0.9(10)	0.9(10)	0.8(1)	0.8(1)	0.8(1)	0.9(10)	0.8(1)	0.9(10)	0.9(10)
Σ notes	68	59	53	29	67	16	69	63	70	37
					March					
b	0.6(1)	0.6(1)	0.6(1)	0.6(1)	0.6(1)	0.8(10)	0.7(5)	0.8(10)	0.6(1)	0.6(1)
a	29.7(5)	35.6(3)	29.2(6)	31.2(4)	25.2(7)	15.9(9)	24.3(8)	13.1(10)	25.2(7)	36.2(1)
R^2	0.5(10)	0.5(10)	0.5(10)	0.5(10)	0.5(10)	0.5(10)	0.5(10)	0.5(10)	0.4(1)	0.5(10)
$\bar{E}$	-0.2(10)	2.5(6)	-1.9(7)	-16.7(1)	-8.9(3)	-0.6(9)	-3.1(5)	1.0(8)	-11.3(2)	5.6(4)
SD	70.8(10)	70.9(9)	71.9(7)	71.4(8)	76.4(4)	86.4(3)	72.7(6)	91.8(2)	94.1(1)	73.3(5)
VC	354(1)	28(5)	38(4)	4(10)	8(8)	133(2)	23(6)	94(3)	8(9)	13(7)
$\overline{AE}$	40.6(6)	38.9(10)	42.1(5)	49.7(2)	39.7(8)	45.8(4)	40.5(7)	46.7(3)	51.5(1)	39.6(9)
RMS	68.9(10)	69.0(9)	70.1(7)	71.5(6)	74.9(4)	84.1(3)	70.9(8)	89.3(2)	92.3(1)	71.6(5)
RMSS	0.5(4)	0.6(6)	0.5(4)	0.3(2)	1.1(10)	0.8(6)	0.9(10)	1.1(10)	2.0(1)	0.6(6)
Σ notes	57	60	51	44	55	47	65	58	24	48

Continues…

DOI: 10.1590/S0100-204X2014000700001

Table 4. Continuation...

					April					
b	0.7(5)	0.7(5)	0.7(5)	0.7(5)	0.8(7)	0.2(1)	0.8(7)	0.8(7)	0.8(7)	0.9(10)
a	13.8(5)	15.6(3)	15.0(4)	19.7(2)	8.3(9)	31.3(1)	12.7(7)	8.5(8)	12.9(6)	4.5(10)
R^2	0.8(7)	0.8(7)	0.8(7)	0.8(7)	0.9(10)	0.1(1)	0.7(5)	0.9(10)	0.9(10)	0.8(7)
$\bar{E}$	0.3(7)	-0.7(6)	0.1(10)	-2.8(2)	1.3(5)	2.3(3)	-4.9(1)	1.7(4)	-0.3(7)	-0.2(8)
SD	22.1(4)	22.1(4)	21.8(5)	24.0(2)	16.8(9)	17.1(8)	29.7(1)	16.1(10)	18.3(7)	21.3(6)
VC	65(3)	30(5)	292(1)	8(8)	12(6)	7(9)	6(10)	9(7)	53(4)	122(2)
$\bar{E}$	15.4(5)	15.9(4)	15.4(5)	17.7(3)	12.0(9)	14.3(7)	19.6(1)	11.2(10)	12.3(8)	15.2(6)
RMS	21.6(3)	21.5(4)	21.3(5)	23.6(2)	16.4(9)	16.8(8)	29.3(1)	15.8(10)	17.9(7)	20.7(6)
RMSS	0.5(4)	0.4(1)	0.5(4)	0.4(1)	0.7(7)	1.0(10)	0.8(8)	0.6(6)	0.5(4)	1.4(6)
Σ notes	43	39	46	32	71	48	41	72	60	61
					May					
b	0.2(10)	0.2(10)	0.2(10)	0.2(10)	0.2(10)	0.2(10)	0.2(10)	0.2(10)	0.2(10)	0.2(10)
a	19.5(9)	20.6(7)	21.3(5)	22.5(3)	21.3(5)	21.3(5)	20.4(8)	22.9(1)	19.4(10)	22.8(2)
R^2	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.2(10)	0.1(1)
$\bar{E}$	3.5(1)	2.9(3)	2.4(6)	1.7(8)	2.6(5)	2.3(7)	2.7(4)	1.5(10)	3.4(2)	1.5(10)
SD	17.1(8)	17.1(8)	17.2(6)	17.4(4)	17.4(4)	17.1(8)	17.2(6)	17.5(2)	16.9(10)	17.5(1)
VC	4(10)	6(8)	7(5)	10(3)	6(6)	7(4)	6(7)	11(1)	5(9)	11(2)
$\bar{AE}$	14.1(7)	14.4(3)	14.5(2)	14.7(1)	14.7(1)	14.3(5)	14.7(1)	14.7(1)	13.9(10)	14.7(1)
RMS	17.0(3)	16.9(7)	16.9(7)	17.1(1)	17.1(1)	16.8(10)	17.0(3)	17.1(1)	16.8(10)	17.1(1)
RMSS	1.3(1)	1.1(5)	1.1(5)	1.0(10)	1.1(5)	1.0(10)	1.0(10)	1.0(10)	1.1(5)	1.0(10)
Σ notes	50	52	47	43	38	60	50	37	76	38
Indicador[(1)]	C	S	P	E	G	R	H	K	J	St
					June					
b	0.3(7)	0.2(3)	0.2(3)	0.1(1)	0.6(10)	0.2(3)	0.2(3)	0.1(1)	0.1(1)	0.1(1)
a	10.8(9)	11.5(8)	14.0(6)	16.3(2)	6.1(10)	13.6(7)	16.1(3)	15.7(5)	18.6(1)	15.7(5)
R^2	0.2(5)	0.2(5)	0.1(1)	0.1(1)	0.3(10)	0.2(5)	0.1(1)	0.1(1)	0.1(1)	0.1(1)
$\bar{E}$	2.1(3)	2.0(4)	2.5(1)	1.1(9)	1.8(6)	2.1(3)	-0.5(10)	1.4(8)	1.9(5)	1.4(8)
SD	15.9(9)	16.0(8)	16.1(7)	16.7(3)	16.9(1)	15.8(10)	16.6(4)	16.5(5)	16.8(2)	16.5(5)
VC	7(9)	8(7)	6(10)	14(2)	9(5)	7(8)	31(1)	12(3)	8(6)	12(4)
$\bar{AE}$	11.6(8)	11.9(7)	12.0(6)	12.8(2)	10.8(10)	11.6(8)	12.8(2)	12.6(4)	13.1(1)	12.6(4)
RMS	15.6(9)	15.7(8)	15.9(7)	16.3(3)	16.5(1)	15.5(10)	16.2(4)	16.1(6)	16.4(2)	16.2(4)
RMSS	0.9(10)	0.8(7)	0.9(10)	0.7(4)	0.9(10)	0.7(4)	0.6(1)	0.7(4)	0.7(4)	0.7(4)
Σ notes	69	57	51	27	64	58	29	37	23	36
					July					
b	0.2(10)	0.2(10)	0.2(10)	0.1(1)	0.2(10)	0.1(1)	0.2(10)	0.2(10)	0.1(1)	0.2(10)
a	4.5(10)	4.6(7)	4.7(5)	5.0(1)	4.5(10)	4.9(3)	4.6(7)	4.7(5)	4.9(3)	4.7(5)
R^2	0.2(10)	0.1(1)	0.1(1)	0.1(1)	0.2(10)	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.1(1)
$\bar{E}$	-0.3(10)	0.3(10)	0.3(10)	0.3(10)	-0.3(10)	0.3(10)	0.3(10)	0.3(10)	0.4(1)	0.3(10)
SD	4.0(10)	4.1(7)	4.1(7)	4.2(3)	4.0(10)	4.2(3)	4.1(7)	4.1(7)	4.3(1)	4.1(7)
VC	15(2)	12(9)	14(4)	16(1)	13(5)	13(6)	14(3)	12(8)	10(10)	12(7)
$\bar{AE}$	3.1(10)	3.3(5)	3.3(5)	3.4(3)	3.2(7)	3.4(3)	3.2(7)	3.3(5)	3.5(1)	3.3(5)
RMS	3.9(10)	4.0(7)	4.0(7)	4.1(3)	3.9(10)	4.1(3)	4.0(7)	4.0(7)	4.2(1)	4.0(7)
RMSS	1.0(10)	0.9(5)	0.9(5)	0.8(1)	0.9(5)	0.8(1)	0.9(5)	1.0(10)	1.0(10)	0.9(5)
Σ notes	82	61	54	24	77	31	57	64	29	57
					August					
b	0.3(3)	0.3(3)	0.2(1)	0.2(1)	0.5(10)	0.2(1)	0.5(10)	0.4(7)	0.5(10)	0.4(7)
a	2.1(4)	2.2(3)	2.4(2)	2.6(1)	1.6(8)	2.6(1)	1.4(10)	1.7(6)	1.4(10)	1.9(5)
R^2	0.5(7)	0.5(7)	0.4(3)	0.3(1)	0.6(10)	0.3(1)	0.6(10)	0.6(10)	0.5(7)	0.5(7)
$\bar{E}$	0.0(10)	0.0(10)	0.0(10)	0.0(10)	0.1(1)	0.0(10)	0.1(1)	0.1(1)	0.1(1)	0.1(1)
SD	1.2(6)	1.2(6)	1.3(4)	1.4(1)	1.0(10)	1.4(1)	1.1(8)	1.1(8)	1.1(8)	1.1(8)
VC	62(5)	93(3)	401(1)	92(4)	11(8)	222(2)	7(9)	15(7)	7(10)	20(6)
$\bar{AE}$	0.9(7)	1.0(3)	1.0(3)	1.1(1)	0.8(10)	1.1(1)	0.8(10)	0.8(10)	0.9(7)	0.9(7)
RMS	1.2(4)	1.2(4)	1.3(2)	1.4(1)	1.0(10)	1.3(2)	1.0(10)	1.1(8)	1.0(10)	1.1(8)
RMSS	0.8(5)	0.8(5)	0.8(5)	0.8(5)	0.9(10)	0.8(5)	1.1(10)	0.8(5)	1.2(5)	0.7(1)
Σ notes	51	44	31	25	77	24	78	62	68	50
					September					
b	0.6(3)	0.5(1)	0.6(3)	0.5(1)	0.7(7)	0.6(3)	0.8(10)	0.6(3)	0.7(7)	0.7(7)
a	1.5(8)	1.5(8)	1.5(8)	1.8(1)	1.1(3)	1.4(6)	0.7(10)	1.2(4)	1.0(2)	1.2(4)
R^2	0.8(10)	0.8(10)	0.8(10)	0.7(1)	0.8(10)	0.8(10)	0.7(1)	0.8(10)	0.8(10)	0.8(10)
$\bar{E}$	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.0(10)	0.1(1)	0.0(10)	0.1(1)
SD	1.8(8)	1.9(6)	1.9(6)	2.1(1)	1.6(10)	1.8(8)	2.0(4)	1.6(10)	1.6(10)	1.6(10)
VC	21(3)	19(5)	20(4)	18(6)	16(7)	13(10)	317(1)	15(9)	33(2)	16(8)
$\bar{AE}$	1.2(6)	1.3(4)	1.3(4)	1.5(1)	1.0(10)	1.1(8)	1.3(4)	1.0(10)	1.0(10)	1.0(10)
RMS	1.8(6)	1.8(6)	1.8(6)	2.1(1)	1.6(10)	1.7(8)	1.9(4)	1.6(10)	1.6(10)	1.6(10)
RMSS	0.6(5)	0.5(1)	0.6(5)	0.5(1)	0.5(1)	0.5(1)	1.3(10)	0.5(1)	0.6(5)	0.5(1)
Σ notes	50	42	47	14	59	55	54	58	66	61

[(1)]b, angular coefficient; a, intersection; R^2, coefficient of determination; $\bar{E}$, mean prediction errors; SD, standard deviation of prediction errors; VC, coefficient of variation; $\bar{AE}$, mean prediction absolute errors; RMS, root-mean-square prediction errors; RMSS, root-mean-square standardized prediction errors.

Table 5. Cross-validation indicators and grades attributed (in brackets), in the second year of evaluation, obtained from ordinary kriging, for the following semivariogram models: C, circular; S, spherical; P, pentaspherical; E, exponential; G, Gaussian; R, rational quadratic; H, hole effect; K, K-Bessel; J, J-Bessel; and St, stable.

Indicador(1)	C	S	P	E	G	R	H	K	J	St
					October					
b	0.6(5)	0.5(1)	0.5(1)	0.5(1)	0.8(10)	0.5(1)	0.8(10)	0.6(5)	0.8(10)	0.6(5)
a	4.3(5)	4.6(4)	5.3(2)	5.1(3)	2.6(10)	5.4(1)	3.3(8)	4.0(7)	3.1(9)	4.3(5)
R^2	0.1(1)	0.1(1)	0.1(1)	0.1(1)	0.3(10)	0.1(1)	0.2(5)	0.2(5)	0.3(10)	0.1(1)
Ē	-0.6(8)	-0.4(10)	-0.8(5)	-0.7(7)	-0.9(4)	-0.7(7)	-1.3(2)	-0.8(5)	-1.7(1)	-1.1(3)
SD	5.2(5)	5.3(4)	5.6(1)	5.5(3)	4.8(10)	5.6(1)	4.8(10)	4.9(8)	4.9(8)	5.0(6)
VC	9(2)	12(1)	7(5)	8(3)	5(7)	7(4)	3(9)	5(6)	2(10)	4(8)
ĀĒ	4.3(1)	4.3(1)	4.3(1)	4.3(1)	3.7(10)	4.3(1)	3.8(8)	4.0(6)	4.0(6)	4.1(4)
RMS	5.1(4)	5.2(3)	5.5(1)	5.4(2)	4.7(10)	5.5(1)	4.8(8)	4.8(8)	5.1(4)	4.9(6)
RMSS	0.3(5)	0.3(5)	0.2(1)	0.3(5)	0.6(10)	0.2(1)	0.3(5)	0.3(5)	0.3(5)	0.3(5)
Σ notes	37	30	18	26	81	18	65	55	63	43
					November					
b	0.5(3)	0.5(3)	0.4(1)	0.4(1)	0.7(10)	0.5(3)	0.7(10)	0.6(7)	0.7(10)	0.6(7)
a	7.4(4)	7.6(3)	8.5(2)	9.2(1)	5.0(8)	7.2(5)	4.1(10)	6.5(7)	4.3(9)	6.6(6)
R^2	0.1(5)	0.1(5)	0.1(5)	0.0(1)	0.1(5)	0.1(5)	0.2(10)	0.1(5)	0.2(10)	0.1(5)
Ē	-0.1(5)	-0.2(1)	-0.2(1)	-0.2(1)	0.0(10)	-0.1(5)	0.0(10)	-0.1(5)	0.0(10)	-0.1(5)
SD	6.3(4)	6.5(3)	7.0(2)	7.4(1)	5.3(10)	6.2(5)	5.3(10)	5.9(6)	5.4(8)	5.9(6)
VC	46(7)	41(8)	32(9)	30(10)	107(3)	49(5)	239(1)	55(4)	156(2)	46(6)
ĀĒ	4.6(4)	4.7(3)	4.9(2)	5.1(1)	3.8(8)	4.5(5)	3.7(10)	4.2(7)	3.8(8)	4.3(6)
RMS	6.1(4)	6.3(3)	6.8(2)	7.2(1)	5.2(9)	6.0(5)	5.1(10)	5.7(7)	5.3(8)	5.8(6)
RMSS	0.6(1)	0.6(1)	0.7(10)	0.7(10)	0.7(10)	0.6(1)	0.6(1)	0.6(1)	0.6(1)	0.6(1)
Σ notes	37	30	34	27	73	39	72	49	66	48
					December					
b	0.6(8)	0.5(6)	0.4(4)	0.2(1)	0.7(9)	0.2(1)	0.7(9)	0.4(4)	0.8(10)	0.3(2)
a	10.0(7)	11.2(6)	12.4(5)	15.4(3)	7.4(9)	17.4(1)	8.7(8)	12.6(4)	6.6(10)	15.5(2)
R^2	0.1(10)	0.0(1)	0.0(1)	0.0(1)	0.1(10)	0.0(1)	0.1(10)	0.0(1)	0.1(10)	0.0(1)
ĀĒ	-1.0(5)	-1.4(4)	-0.8(6)	-0.1(10)	-1.7(3)	-0.2(9)	-1.8(2)	-0.7(7)	-3.1(1)	-0.3(8)
SD	8.4(10)	8.6(8)	9.3(6)	11.3(2)	8.7(7)	12.6(1)	8.6(8)	9.5(5)	9.8(4)	11.3(2)
VC	8(6)	6(7)	11(5)	88(1)	5(8)	79(2)	4(9)	14(4)	3(10)	40(3)
ĀĒ	6.6(10)	6.9(7)	7.3(4)	8.7(2)	6.6(10)	9.6(1)	6.7(8)	7.3(4)	7.2(6)	8.7(2)
RMS	8.2(10)	8.5(9)	9.1(6)	11.0(2)	8.7(7)	12.3(1)	8.6(8)	9.2(5)	10.0(4)	11.0(2)
RMSS	0.6(3)	0.5(1)	0.6(3)	0.7(7)	0.8(10)	0.7(7)	0.6(3)	0.6(3)	0.7(7)	0.6(3)
Σ notes	69	49	40	28	73	24	65	33	62	25
					January					
b	0.5(7)	0.5(7)	0.5(7)	0.4(3)	0.4(3)	0.2(1)	0.6(10)	0.4(3)	0.6(10)	0.4(3)
a	9.9(8)	10.2(7)	10.2(7)	12.1(2)	10.6(4)	15.2(1)	7.5(10)	10.5(5)	8.1(9)	10.7(3)
R^2	0.0(1)	0.0(1)	0.0(1)	0.0(1)	0.0(1)	0.0(1)	0.1(10)	0.0(1)	0.1(10)	0.0(1)
Ē	0.6(3)	0.4(8)	0.5(7)	0.1(10)	0.3(9)	0.6(3)	0.7(1)	-0.4(8)	0.7(1)	0.5(7)
SD	8.2(5)	8.3(3)	8.3(3)	8.6(2)	7.7(8)	9.7(1)	6.8(10)	7.8(7)	7.3(9)	8.2(5)
VC	13(8)	20(4)	15(7)	76(1)	22(2)	15(6)	9(10)	20(3)	10(9)	16(5)
ĀĒ	6.0(5)	6.1(3)	6.1(3)	6.5(2)	5.8(8)	7.4(1)	4.8(10)	5.9(7)	5.2(9)	6.0(5)
RMS	8.0(5)	8.1(3)	8.1(3)	8.4(2)	7.5(8)	9.5(1)	6.7(10)	7.6(7)	7.1(9)	8.0(5)
RMSS	1.3(1)	1.2(3)	1.3(1)	0.9(7)	0.9(7)	1.0(10)	1.3(1)	0.9(7)	1.3(1)	1.1(7)
Σ notes	43	39	39	30	40	25	72	47	67	41
					February					
b	0.6(7)	0.6(7)	0.6(7)	0.5(3)	0.7(10)	0.4(1)	0.7(10)	0.6(7)	0.7(10)	0.6(7)
a	10.7(5)	10.9(4)	10.7(5)	12.9(2)	9.3(8)	15.0(1)	7.2(10)	9.6(7)	8.6(9)	9.6(7)
R^2	0.1(10)	0.1(10)	0.1(10)	0.0(1)	0.1(10)	0.0(1)	0.1(10)	0.1(10)	0.1(10)	0.1(10)
Ē	0.3(4)	0.2(6)	-0.1(8)	-0.1(8)	0.0(10)	0.3(4)	-0.2(6)	-0.4(2)	-0.5(1)	0.4(2)
SD	9.7(5)	9.8(4)	10.2(3)	10.2(3)	9.0(10)	11.3(1)	9.3(7)	9.3(7)	9.5(6)	9.2(8)
VC	30(4)	39(5)	112(8)	126(9)	433(10)	42(6)	59(7)	25(3)	18(1)	23(2)
ĀĒ	7.3(5)	7.3(5)	7.6(3)	7.7(2)	6.5(10)	8.3(1)	7.0(7)	7.0(7)	7.3(5)	6.8(9)
RMS	9.4(5)	9.6(4)	9.9(3)	10.0(2)	8.7(10)	11.0(1)	9.0(8)	9.1(7)	9.2(6)	8.9(9)
RMSS	1.1(7)	1.1(7)	1.0(10)	0.9(7)	1.1(7)	1.0(10)	1.5(1)	1.1(7)	1.4(3)	1.0(10)
Σ notes	52	52	57	37	85	26	66	57	51	64
					March					
b	0.7(10)	0.5(3)	0.4(1)	0.6(7)	0.6(7)	0.6(7)	0.7(10)	0.6(7)	0.7(10)	0.6(7)
a	20.4(8)	35.6(4)	49.2(1)	34.7(5)	20.5(7)	26.3(6)	13.1(10)	36.0(3)	15.0(9)	36.3(2)
R^2	0.0(1)	0.0(1)	0.0(1)	0.0(1)	0.0(1)	0.0(1)	0.1(10)	0.0(1)	0.0(1)	0.0(1)
Ē	-13.3(1)	6.1(7)	5.2(9)	-6.1(7)	-9.5(3)	-3.7(10)	-9.1(4)	8.5(6)	-8.9(5)	-9.9(2)
SD	63.3(5)	73.6(2)	82.8(1)	67.1(4)	48.0(8)	62.4(6)	37.5(10)	68.0(3)	40.9(9)	53.4(7)
VC	4(9)	12(3)	16(2)	10(4)	5(7)	17(1)	3(10)	8(5)	4(8)	5(6)
ĀĒ	43.9(2)	38.3(5)	52.3(1)	42.1(3)	29.2(8)	38.3(5)	24.2(10)	35.8(6)	25.5(9)	31.8(7)
RMS	63.0(5)	71.9(2)	80.7(1)	65.6(4)	47.7(8)	60.8(6)	37.6(10)	66.8(3)	40.8(9)	53.0(7)
RMSS	0.3(2)	0.6(5)	0.5(4)	0.4(3)	0.8(8)	0.4(3)	2.0(1)	0.9(10)	1.2(8)	0.7(6)
Σ notes	43	32	19	38	57	45	75	44	68	45

Continues…

Table 5. Continuation...

April										
b	0.9(10)	0.9(10)	0.9(10)	0.9(10)	0.9(10)	0.9(10)	0.9(10)	0.9(10)	0.9(10)	0.9(10)
a	2.7(5)	3.6(4)	3.9(3)	5.1(1)	1.3(8)	4.9(2)	2.7(5)	1.2(10)	1.4(7)	1.2(10)
R^2	0.3(4)	0.3(4)	0.2(7)	0.2(7)	0.7(1)	0.2(7)	0.3(4)	0.8(10)	0.6(2)	0.8(10)
Ē	-1.5(7)	-2.6(5)	-3.0(2)	-3.6(1)	1.1(10)	-2.7(4)	-2.8(3)	1.1(10)	-2.4(6)	1.1(10)
SD	10.9(7)	11.1(5)	11.6(4)	12.4(3)	10.3(10)	11.1(5)	17.9(1)	10.3(10)	13.8(2)	10.3(10)
VC	7(4)	4(7)	3(9)	3(10)	9(2)	4(8)	6(5)	9(1)	5(6)	9(2)
ĀĒ	9.5(6)	9.8(5)	9.9(4)	10.7(2)	7.9(10)	9.2(7)	13.1(1)	7.9(10)	10.3(3)	7.9(10)
RMS	10.7(7)	11.1(5)	11.6(4)	12.6(3)	10.1(10)	11.1(5)	17.6(1)	10.1(10)	13.7(2)	10.1(10)
RMSS	0.5(7)	0.4(3)	0.4(3)	0.4(3)	1.4(8)	0.4(3)	2.0(1)	1.3(10)	2.0(1)	1.4(8)
Σ notes	57	48	46	40	69	51	31	81	46	80
May										
b	0.5(5)	0.5(5)	0.3(3)	0.3(3)	0.7(8)	0.2(1)	0.8(10)	0.7(8)	0.8(10)	0.7(8)
a	11.0(4)	11.0(4)	15.3(3)	17.2(2)	5.2(8)	20.7(1)	3.9(10)	7.1(6)	5.0(9)	6.7(7)
R^2	0.0(1)	0.0(1)	0.0(1)	0.0(1)	0.1(5)	0.0(1)	0.2(10)	0.1(5)	0.2(10)	0.1(5)
ĀĒ	0.9(6)	1.0(5)	0.6(7)	0.5(8)	-1.7(3)	0.4(10)	-0.4(10)	-1.9(1)	-1.5(4)	-1.9(1)
SD	11.3(8)	11.3(8)	12.0(3)	12.1(2)	10.9(9)	13.2(1)	10.2(10)	11.5(6)	11.2(9)	11.6(5)
VC	12(5)	11(6)	18(4)	25(3)	6(8)	33(1)	25(2)	6(9)	7(7)	6(10)
ĀĒ	8.4(6)	8.3(7)	9.8(3)	10.0(2)	8.1(9)	11.1(1)	7.3(10)	8.2(8)	8.6(5)	8.3(7)
RMS	11.1(6)	11.0(7)	11.7(3)	11.8(2)	10.8(9)	12.8(1)	9.9(10)	11.3(5)	11.0(7)	11.4(4)
RMSS	1.1(10)	1.1(10)	1.2(7)	1.1(10)	2.0(1)	1.1(10)	2.0(1)	1.7(5)	2.0(1)	1.8(3)
Σ notes	51	53	34	33	60	27	73	53	62	50
June										
b	0.3(10)	0.3(10)	0.3(10)	0.2(1)	0.3(10)	0.2(1)	0.3(10)	0.2(1)	0.3(10)	0.3(10)
a	8.5(8)	9.2(6)	9.6(2)	11.0(1)	9.2(6)	9.3(4)	7.6(10)	9.4(3)	8.1(9)	9.1(7)
R^2	0.0(10)	0.0(10)	0.0(10)	0.0(10)	0.0(10)	0.0(10)	0.0(10)	0.0(10)	0.0(10)	0.0(10)
Ē	2.2(9)	2.4(7)	2.2(9)	2.0(10)	-2.4(7)	2.6(3)	-2.7(2)	2.5(5)	-2.8(1)	2.5(5)
SD	9.6(8)	10.0(5)	10.0(5)	10.7(1)	9.9(7)	10.2(2)	9.5(10)	10.1(4)	9.5(10)	10.0(5)
VC	47(3)	46(5)	42(2)	52(1)	46(5)	39(8)	36(9)	44(6)	34(10)	40(7)
ĀĒ	7.2(8)	7.5(5)	7.5(5)	8.0(1)	7.4(7)	7.7(2)	7.1(9)	7.6(3)	7.0(10)	7.5(5)
RMS	9.6(10)	10.0(6)	10.0(6)	10.6(1)	10.0(6)	10.2(2)	9.7(8)	10.1(4)	9.7(8)	10.0(6)
RMSS	1.1(5)	1.0(10)	0.9(5)	0.9(5)	1.0(10)	1.0(10)	1.3(1)	1.0(10)	1.0(10)	1.0(10)
Σ notes	71	64	54	31	63	42	69	46	78	65
July										
b	0.5(6)	0.4(4)	0.4(4)	0.2(1)	0.6(8)	0.2(1)	0.7(10)	0.3(2)	0.4(4)	0.3(2)
a	3.2(8)	3.6(6)	3.9(5)	5.1(1)	2.0(10)	4.9(2)	2.7(9)	4.3(3)	3.5(7)	4.3(3)
R^2	0.1(5)	0.1(5)	0.1(5)	0.0(1)	0.3(10)	0.0(1)	0.3(10)	0.1(5)	0.1(5)	0.1(5)
Ē	0.7(5)	0.7(5)	0.6(8)	0.5(9)	0.7(5)	0.7(5)	-0.2(10)	0.7(5)	0.9(1)	0.7(5)
SD	4.1(10)	4.2(8)	4.3(6)	4.9(3)	4.2(8)	4.9(3)	5.4(1)	4.5(5)	4.3(6)	4.6(4)
VC	6(7)	6(7)	7(5)	9(2)	5(9)	8(3)	21(1)	7(5)	4(10)	7(5)
ĀĒ	3.0(8)	3.1(7)	3.2(5)	3.7(1)	2.9(9)	3.5(2)	3.2(5)	3.3(3)	2.7(10)	3.3(3)
RMS	4.0(10)	4.1(9)	4.2(8)	4.8(3)	4.2(8)	4.8(3)	5.2(1)	4.5(5)	4.3(6)	4.5(5)
RMSS	0.8(7)	0.7(3)	0.6(1)	0.7(3)	0.9(10)	0.7(3)	1.1(10)	0.7(3)	0.7(3)	0.7(3)
Σ notes	66	54	47	24	77	23	57	36	52	34
August										
b	0.3(3)	0.3(3)	0.2(1)	0.2(1)	0.5(10)	0.2(1)	0.5(10)	0.3(3)	0.4(7)	0.3(3)
a	3.0(6)	3.1(4)	3.3(3)	3.8(1)	1.8(10)	3.4(2)	1.8(10)	3.0(6)	2.2(8)	2.9(7)
R^2	0.1(3)	0.1(3)	0.1(3)	0.0(1)	0.3(10)	0.1(3)	0.3(10)	0.1(3)	0.2(7)	0.1(3)
Ē	0.7(3)	0.6(7)	0.6(7)	0.4(10)	0.9(1)	0.6(7)	0.7(3)	0.7(3)	0.9(1)	0.7(3)
SD	2.8(6)	2.9(4)	2.9(4)	3.1(1)	2.6(10)	3.0(2)	2.8(6)	2.8(6)	2.6(10)	2.7(8)
VC	41(5)	46(4)	52(2)	75(1)	30(10)	51(3)	39(8)	40(7)	31(9)	40(7)
ĀĒ	2.3(5)	2.4(3)	2.4(3)	2.6(1)	2.0(10)	2.4(3)	2.2(7)	2.3(5)	2.1(9)	2.2(7)
RMS	2.8(6)	2.8(6)	2.9(3)	3.1(1)	2.6(10)	2.9(3)	2.9(3)	2.8(6)	2.7(8)	2.7(8)
RMSS	0.9(7)	0.9(7)	0.8(5)	0.9(7)	1.4(1)	0.9(7)	1.3(3)	0.9(7)	1.0(10)	0.9(7)
Σ notes	44	41	31	24	72	31	60	46	69	53
September										
b	0.2(3)	0.2(3)	0.2(3)	0.1(1)	0.3(7)	0.1(1)	0.4(10)	0.1(1)	0.4(10)	0.3(7)
a	2.9(6)	3.2(5)	3.3(4)	3.6(2)	2.1(7)	4.5(1)	1.6(10)	3.5(3)	1.7(9)	2.1(7)
R^2	0.1(3)	0.1(3)	0.0(1)	0.0(1)	0.2(7)	0.0(1)	0.3(10)	0.0(1)	0.2(7)	0.2(7)
Ē	0.9(4)	0.8(6)	0.7(8)	0.6(10)	-1.2(1)	0.7(8)	1.1(2)	0.7(8)	1.1(2)	1.2(1)
SD	3.7(5)	3.8(4)	3.9(3)	4.0(1)	3.2(7)	4.0(1)	2.8(10)	3.9(3)	2.9(9)	3.2(7)
VC	40(6)	46(5)	53(4)	65(1)	26(7)	54(3)	25(10)	57(2)	26(7)	26(7)
ĀĒ	2.8(5)	2.9(3)	2.9(3)	3.0(1)	2.5(7)	2.9(3)	2.2(10)	2.9(3)	2.3(9)	2.5(7)
RMS	3.7(7)	3.8(5)	3.8(5)	4.0(1)	3.3(8)	3.9(3)	3.0(10)	3.9(3)	3.1(9)	3.3(8)
RMSS	0.8(3)	0.7(1)	0.7(1)	0.7(1)	1.0(10)	0.7(1)	1.0(10)	0.7(1)	0.9(7)	1.0(10)
Σ notes	42	35	32	19	61	22	82	25	69	61

(1)b, angular coefficient; a, intersection; R^2, coefficient of determination; Ē, mean prediction errors; SD, standard deviation of prediction errors; VC, coefficient of variation; ĀĒ, mean prediction absolute errors; RMS, root-mean-square prediction errors; RMSS, root-mean-square standardized prediction errors.

DOI: 10.1590/S0100-204X2014000700001

The variability of models obtained for each month reflects the influence of the evaluation time on the spatial distribution of fig fly population density. Between the first and second years, only three months show the same selection of semivariogram models (January, March, and April). However, it would take more years to make a proper comparison among the selected models throughout the months.

The selected models did not present nugget effect, indicating the absence of discontinuity in the semivariogram models, for distances smaller than the smallest distance among the samples (13 m in the present case, between the points 6 and 7) (Webster & Oliver, 2007).

The range of values obtained with the selected semivariogram models were quite variable over the years and months (≥42.2m). In the first year, the lowest values were obtained in October, November, and July, and the highest, in December and February. In the second year, the lowest values were observed in October, November, and December, and the highest, in January. In average, range values were superior in the second year (Tables 2 and 3). However, the reason for this variation could not be explained, since the values of descriptive statistics bear no relation to the estimated parameters of the theoretical semivariogram models. Nielsen & Wendroth (2002) found that the variation range represents the maximum distance of spatial autocorrelation, indicating that the points located in an area whose radius is in its range are more similar to each other than those separated by greater distances. According to Webster & Oliver (2007), the range constitutes the maximum distance of spatial dependence. The obtained results indicate that the distances among the traps were adequate, and that it is possible to determine a rearrangement of trapping range from the results of the smallest range of the selected models.

Conclusions

1. Each data set (months) of fig fly population density has a particular spatial dependence structure, which makes it necessary to define specific models of theoretical semivariograms in order to enhance the adjustment to the experimental semivariogram.

2. It was not possible to determine a standard theoretical semivariogram model; instead, six theoretical models were selected: circular, Gaussian, hole effect, K-Bessel, J-Bessel, and stable.

Acknowledgements

To Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes), for scholarships granted; and to Dionísio Link (*in memoriam*), for research orientation.

References

BOTTEGA, E.L.; QUEIROZ, D.M. de; PINTO, F. de A. de C.; SOUZA, C.M.A. de. Variabilidade espacial de atributos do solo em sistema de semeadura direta com rotação de culturas no cerrado brasileiro. **Revista Ciência Agronômica**, v.44, p.1-9, 2013. DOI: 10.1590/S1806-66902013000100001.

BOX, G.E.P.; COX, D.R. Analysis of transformations. **Journal of the Royal Statistical Society**, v.26, p.211-243, 1964.

DINARDO-MIRANDA, L.L.; FRACASSO, J.V. Spatial and temporal variability of plant-parasitic nematodes population in sugarcane. **Bragantia**, v.69, p.39-52, 2010. DOI: 10.1590/S0006-87052010000500006.

ELLSBURY, M.M.; WOODSON, W.D.; CLAY, S.A.; MALO, D.; SCHUMACHER, J.; CLAY, D.E.; CARLSON, C.G. Geostatistical characterization of the spatial distribution of adult corn rootworm (Coleoptera: Chrysomelidae) emergence. **Environmental Entomology**, v.27, p.910-917, 1998.

FARACO, M.A.; URIBE-OPAZO, M.A.; SILVA, E.A.A. da; JOHANN, J.A.; BORSSOI, J.A. Seleção de modelos de variabilidade espacial para elaboração de mapas temáticos de atributos físicos do solo e produtividade da soja. **Revista Brasileira de Ciência do Solo**, v.32, p.463-476, 2008. DOI: 10.1590/S0100-06832008000200001.

FARIAS, P.R.S.; BARBOSA, J.C.; BUSOLI, A.C.; OVERAL, W.L.; MIRANDA, V.S.; RIBEIRO, S.M. Spatial analysis of the distribution of *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) and losses in maize crop productivity using geostatistics. **Neotropical Entomology**, v.37, p.321-327, 2008. DOI: 10.1590/S1519-566X2008000300012.

GOOVAERTS, P. **Geostatistics for natural resources evaluation**. New York: Oxford University Press, 1997. 496p.

GUNDOGDU, K.S.; GUNEY, I. Spatial analyses of groundwater levels using universal kriging. **Journal of Earth System Science**, v.116, p.49-55, 2007. DOI: 10.1007/s12040-007-0006-6.

HELDWEIN, A.B.; BURIOL, A.G.; STRECK, N.A. O clima de Santa Maria. **Ciência e Ambiente**, v.38, p.43-58, 2009.

JOHNSON, K; VER HOEF, J.M.; KRIVORUCHKO, K.; LUCAS, N. **ArcGIS 9**: using ArcGIS geostatistical analyst. Redlands: ESRI, 2001. 306p.

LASMAR, O.; ZANETTI, R.; DOS SANTOS, A.; FERNANDES, B.V. Use of geostatistics to determine the spatial distribution and infestation rate of leaf-cutting ant nests (Hymenoptera: Formicidae) in eucalyptus plantations. **Neotropical Entomology**, v.41, p.324-332, 2012. DOI: 10.1007/s13744-012-0040-1.

MELLO, J.M. de; BATISTA, J.L.F.; RIBEIRO JÚNIOR, P.J.; OLIVEIRA, M.S. de. Ajuste e seleção de modelos espaciais de semivariograma visando à estimativa volumétrica de *Eucalyptus grandis*. **Scientia Forestalis**, v.69, p.25-37, 2005.

MORA, A.; BEER, J. Geostatistical modeling of the spatial variability of coffee fine roots under *Erythrina* shade trees and contrasting soil management. **Agroforestry Systems**, v.87, p.365-376, 2013. DOI: 10.1007/s10457-012-9557-x.

NIELSEN, D.R.; WENDROTH, O. **Spatial and temporal statistics**. Reiskirchen: Catena Verlag GMBH, 2002. 398p.

NOETZOLD, R.; ALVES, M. de C.; CASSETARI NETO, D.; MACHADO, A.Q. Variabilidade espacial de *Colletotrichum truncatum* em campo de soja sob três níveis de sanidade de sementes. **Summa Phytopathologica**, v.40, p.16-23, 2014. DOI: 10.1590/S0100-54052014000100002.

PASINI, M.P.B.; LINK, D. Efficiency of different traps to capture *Zaprionus indianus* (Diptera: Drosophilidae) in fig orchard in Santa Maria county, Rio Grande do Sul State, Brazil. **International Research Journal of Agricultural Science and Soil Science**, v.1, p.349-354, 2011.

PASINI, M.P.B.; LINK, D.; SCHAICH, G. Attractive solutions efficiency in capturing *Zaprionus indianus* Gupta, 1970 (Diptera: Drosophilidae) in *Ficus carica* L. (Moraceae) orchard in Santa Maria, Rio Grande do Sul, Brazil. **Entomotropica**, v.26, p.107-116, 2011.

RAGA, A.; MACHADO, R.A.; DINARDO, W.; STRIKIS, P.C. Eficácia de atrativos alimentares na captura de moscas-das-frutas em pomar de citros. **Bragantia**, v.65, p.337-345, 2006. DOI: 10.1590/S0006-87052006000200016.

SILVA, A.F. da; LIMA, J.S. de S.; OLIVEIRA, R.B. de. Métodos de interpolação para estimar o pH em solo sob dois manejos de café arábica. **Idesia**, v.28, p.61-66, 2010. DOI: 10.4067/S0718-34292010000200007.

WEBSTER, R.; OLIVER, M.A. **Geostatistics for environmental scientists**. 2nd ed. Chichester: J. Wiley, 2007. 330p. DOI: 10.1002/9780470517277.

YAMAMOTO, J.K.; LANDIM, P.M.B. **Geoestatística**: conceitos e aplicações. São Paulo: Oficina de textos, 2013. 215p.

YASSIN, A.; DAVID, J.R. Revision of the afrotropical species of *Zaprionus* (Diptera, Drosophilidae), with descriptions of two new species and notes on internal reproductive structures and immature stages. **Zookeys**, v.51, p.33-72, 2010. DOI: 10.3897/zookeys.51.380.

Received on January 10, 2014 and accepted on June 16, 2014